Quantitative assessment of an interobserver delineation margin for breast radiotherapy treatment planning

Poster No.: R-0184
Congress: 2014 CSM
Type: Scientific Exhibit
Authors: L. Bell, E. Pogson, P. Metcalfe, L. Holloway; WOLLONGONG/AU
Keywords: Radiotherapy techniques, Cancer, Physics, Radiation therapy / Oncology, Segmentation, CT, Radiation physics, Breast
DOI: 10.1594/ranzcr2014/R-0184

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply RANZCR/AIR/ACPSEM's endorsement, sponsorship or recommendation of the third party, information, product or service. RANZCR/AIR/ACPSEM is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold RANZCR/AIR/ACPSEM harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, .ppt presentations, .doc documents and any other multimedia files are not available in the pdf version of presentations.
Aim

Accounting for uncertainties in radiotherapy is essential in ensuring that the planned dose distribution is delivered as intended for every fraction. Modern radiotherapy and imaging techniques have become increasingly accurate, resulting in increased dose precision and accuracy. Uncertainties arising from reproducibility in set up as well as tumour and patient motion can now be somewhat detected prior to, or during treatment, enabling their impact to be reduced.

One type of uncertainty that is minimally affected by technique improvements is interobserver variation in target volume delineation. Interobserver variation occurs when the target volume for a particular patient, is inconsistently delineated amongst different observers. This uncertainty for breast has been determined to be significant and its presence results in a systematic shift of the dose distribution [1,3]. As the margins that account for other uncertainties are decreased, the effect of interobserver variability becomes relatively greater, resulting in under dosage to the target volume and overdosing the surrounding normal tissue.

A number of studies have investigated the spatially varying nature of interobserver variation [4,5,6]. It has been found to be dependent on the anatomical location at which it is investigated, resulting in the necessity of an anisotropic margin to adequately account for this uncertainty.

It is apparent that a clinical target volume (CTV) to planning target volume (PTV) margin that incorporates interobserver delineation uncertainty is increasingly necessary in modern radiotherapy. The ICRU report 62 recommends that when defining a margin, different types of uncertainties be added in quadrature, implying they have equal weightings [7]. In contrast however, studies defining CTV to PTV margin recipes have collectively found that systematic uncertainties have a larger affect on the dose distribution than the random uncertainties [1,2]. As such, the determined margin recipes involve the weighted sum of the systematic uncertainties and random uncertainties. The systematic component is often approximately 3 times greater than the random component, with a coefficient between 2 and 2.5 [1,2]. Although the published margin recipes acknowledge that interobserver uncertainty should be included, there has been to our knowledge no methodology presented for determining this margin.

The total systematic uncertainty is the quadrature sum of all the systematic uncertainties [1,2]. Since interobserver delineation variation is entirely systematic in nature, a margin to account for this uncertainty can be investigated separately. This margin could then
be combined with the margin accounting for the other uncertainties to provide a comprehensive margin that accounts for all radiotherapy uncertainties.

This study reports the definition and application of an anisotropic whole breast delineation margin to quantify the encompassment of the CTVs it was derived from.

**Methods and materials**

21 CT whole breast datasets were used in which the clinical target volumes (CTVs) were delineated by 8 observers. The standard deviation (SD) of the contours from the mean was determined at whole angular increments, on all slices.

The patients were divided up into small, medium and large volume categories for both left and right breast patients and further filtered so that only patients of similar shaped CTVs were used. The volume limits of each category are presented in Table 1.

![Table 1: Volume Categories](image)

<table>
<thead>
<tr>
<th></th>
<th>Left Breasts (cm³)</th>
<th>Right Breasts (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>400-800</td>
<td>500-700</td>
</tr>
<tr>
<td>Medium</td>
<td>1000-1400</td>
<td>800-1100</td>
</tr>
<tr>
<td>Large</td>
<td>1401-1810</td>
<td>1700-2100</td>
</tr>
</tbody>
</table>

**References:** Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW||2522, Australia - WOLLONGONG/AU

The margin was defined as 2 times the average SD of all patients within a volume category. This is based on the margin recipe presented by Stroom et al (2#+0.7#) [1]. This recipe was chosen as it used clinical CTVs and dose distributions in its derivation as opposed to theoretical volumes, and it was validated on a variety of anatomical locations. Additionally, the use of the smaller coefficient for systematic uncertainties that is presented in literature, produces a 'worst case scenario' margin in terms of encompassment of CTV volumes.
For each patient, the respective margin was applied to a consensus contour generated from the 8 observer CTVs. The contour was derived using the 'Simultaneous and Truth Performance Level Estimation (STAPLE) algorithm at a 90% confidence level. The volume overlap with each of the CTVs was determined to assess its encompassment of other potential volumes. The percentage overlap is shown in the below equation (Fig 5), with 100% representing complete overlap.

\[
\text{\% Overlap} = \frac{\text{CTV Volume} \cap \text{Margin Volume}}{\text{CTV Volume}}
\]

**Fig. 5**: Equation for percentage overlap of the margin volume with a CTV volume

**References**: Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW 2522, Australia - WOLLONGONG/AU

**Images for this section:**

<table>
<thead>
<tr>
<th>Volume Categories</th>
<th>Left Breasts (cm³)</th>
<th>Right Breasts (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>400-800</td>
<td>500-700</td>
</tr>
<tr>
<td>Medium</td>
<td>1000-1400</td>
<td>800-1100</td>
</tr>
<tr>
<td>Large</td>
<td>1401-1810</td>
<td>1700-2100</td>
</tr>
</tbody>
</table>

**Table 1**: Volume Categories
Results

The volumes created when the margins were applied to the STAPLE contour were observed to be of a reasonable anatomical coverage as seen in Figure 1.

![CT scan image](image)

**Fig. 1**: The coverage of a delineation margin for small CTV volumes (red) with left breast CTVs (yellow), as delineated by 8 observers.

**References**: Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW 2522, Australia - WOLLONGONG/AU

It is important to remember that these margins are a mathematical concept, with the magnitude dependent entirely on the standard deviation of interobserver delineation uncertainty in a particular direction. There were no anatomical limits placed on the margin volumes meaning extension past the patient surface and into the lung often occurred. Anatomically bound margins will be defined in the future to increase clinical feasibility. The large extension in the anterior-medial and posterior-lateral directions however, is indicative of the increased interobserver variation in these regions. The necessity for such a margin in these regions is apparent.
The margin coverage of clinician defined CTVs was assessed as the percentage overlap. An overlap of 95% or greater was arbitrarily considered successful, accounting for some inaccuracy in the contour interpolation process when the origin of the coordinate system lay outside the contour. The range of percentage overlap values and their success in CTV encompassment is presented in Figures 2 and 3.

![Graph](image)

**Fig. 2**: Overlap of the volume when the margin is applied to the STAPLE volume, with each left breast observer contour. A percentage overlap of greater than 95% is considered successful.

**References**: Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW||2522, Australia - WOLLONGONG/AU
Fig. 3: Overlap of the volume when the margin is applied to the STAPLE volume, with each right breast observer contour.

References: Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW 2522, Australia - WOLLONGONG/AU

As CTV volume decreases, the effectiveness of the margin in encompassing all observer contours decreases. When applied to the largest contour, 100% of patients CTVs were successfully encompassed for both the right and left breast cases. The encompassment for small CTV volumes is worse at superior and inferior slices as seen in Figure 4.
Fig. 4: Poor margin (red) encompassment of CTV volumes (yellow colour wash) at an inferior slice. Sharp edges of the margin volume are due to inaccuracies in the interpolation.

References: Centre for Medical Radiation Physics, University of Wollongong, Wollongong, NSW||2522, Australia - WOLLONGONG/AU

The left breast margin volumes are in general more successful than right breast margin volumes. Smaller margin volumes fail to encompass 16.7% of volumes for the right breast CTVs as opposed to left breast CTVs where they fail 3.1% of times.

Conclusion

A whole breast anisotropic delineation margin is effective in accounting for interobserver uncertainty. This is apparent when applied to medium and large volume CTVs and for left breast CTVs. The margin is less effective when applied to small volumes, especially for right breast patients. This is perhaps due to the heart providing a more robust landmark at which to base contouring in left breast patients. This would result in smaller interobserver variation in left breast contours resulting in a margin that frequently encompasses all CTVs.
Based on visual observations, a margin is necessary to account for interobserver delineation uncertainty in the anterior-medial and posterior-lateral directions of the whole breast CTV. Such a margin would move towards being clinically feasible if anatomical limits were placed on its magnitude.

Personal information

Lauren Bell

- Centre for Medical Radiation Physics, University of Wollongong, Wollongong
- Liverpool and Macarthur Cancer Therapy Centres, NSW
- Ingham Institute: Applied Medical Research, Liverpool, NSW

E-mail:lb998@uowmail.edu.au

References